Audit of Water and Irrigation Use Efficiencies on Farms within the Queensland Lucerne Industry

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In Conjunction with

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1. Introduction

Key Points

- *Savings from improved water use efficiency (WUE) are a potential source of water for Queensland*
- *DNR will provide assistance of $41 million over four years to assist the Rural Water Use Efficiency Initiative (RWUE)*
- *The Department of Primary Industries is partnering DNR to implement the program for the Lucerne Industry*
- *There will be a range of other benefits that will flow through to the lucerne industry from this initiative.*

Queensland, like the rest of Australia, faces increasing competitive demands for its finite water supply. Over recent years considerable effort has been undertaken to ascertain current supplies and future demands for water. However, there has only been limited assessment of water use efficiency and those efforts have often been on an *ad hoc* and micro basis. The Queensland government has recognised there are three potential sources of additional water for Queensland, which are listed below.

- Savings from improved water use efficiency.
- Reuse of wastewater.
- Additional water supplies through new infrastructure development.

The first of these sources is the focus of the "Rural Water Use Efficiency Initiative" launched by the Queensland Government. The program is a partnership between government and the four main rural industries that use water, dairy, cotton, horticulture and sugarcane. Lucerne has been incorporated under the banner of dairy.

Forty one million dollars will be spent on this initiative over a four year period. Twenty three million dollars will be spent on adoption (extension) programs to improve water use efficiency on farms, with the balance directed towards the other areas of focus.

The Department of Primary Industries (DPI) has agreed to form a partnership with the Department of Natural Resources (DNR) in implementing the lucerne program. This report represents the first stage of this partnership - the evaluation of the lucerne industry's current performance with respect to water use efficiency.

In addition to the establishment of extension programs, this project will yield a range of other benefits for DPI and its stakeholders. These include the following.

- A greater and more comprehensive understanding of the industry.
- An opportunity to appropriately value water for use in lucerne farming enabling farmers to make informed and profitable decisions for the purchase or sale of water.
- Environmental benefits from reduced drainage and deep percolation through water use efficiency.

- The development of closer links with DNR and the other irrigation industries with regard to water management.
- An opportunity for improved identification, management and maintenance of industry information.
- Empirical evidence of current irrigation performance which, along with future improvements, can be used for industry based lobbying for infrastructure development.

2. Project Methodology & Deliverables

Key Points

- *Stage 1 – Survey development, Extension Officer training and completion of surveys*
- *Stage 2 – Database construction and analysis*
- *Stage 3 – Report*
- *Stage 4 – In-region presentation of the report and findings*

There are four major stages to the project which are presented in the following sections.

2.1 Stage 1 – Survey Development and Surveyor Training

Objective

To develop a survey, train surveyors and collate the completed surveys.

Process

1. Project Inception
2. Development of survey structure and content
3. Development pre Survey Training
4. Training conducted

   The training course covered:

   - Water use efficiency concepts
   - Assessment of water use
   - Irrigation practices
   - Technology of Irrigation Systems
   - The improvement process
   - Lessons from experiences
5. Assistance with the Survey Process
   - Review of survey structure and timetable
   - Review of completed surveys to ensure integrity of results

Outcome

91 Lucerne surveys completed and collated.

2.2 Stage 2 – Database Construction and Analysis

Objective

Analysis utilises a database with all available information. The database has been developed in Microsoft Excel and Access format. It has been constructed and documented so that it can be presented, maintained and updated by users on an ongoing basis.

Process

1. Data retrieve and consolidate from existing Australian and international information including:
   - Australian Bureau of Statistics (ABS)
   - Queensland Department of Natural Resources (DNR)
   - Queensland Department of Primary Industries (QDPI)
   - Relevant departments in other states

2. Database Development

   A database has been developed very similar to the development of the QFVG Horticultural Industry database. The database has been primarily developed in Microsoft Excel, which has been exported to Microsoft Access for analysis of industry structure.

Outcome

Four databases that provide:

- An overview of the structure of the industry and water management practices
- An audit of the current industry on a regional basis
- Analysis of best practice
- An assessment of opportunities for improvement by region.

2.3 Stage 3 - Report

Objective

This report includes the developed databases, conclusions and specific recommendations to the industry as well as a WUE target.

The project utilises similar methods of analysis and report structure as developed for QFVG water use efficiency project.

Process

1. Consolidate information obtained during Stages 1 and 2.
2. Develop draft report identifying opportunities for improvement and formulating recommendations to industry.
3. Development of a final report.

Outcome

The report is based on desktop research and the industry participant surveys and provides:

- a comprehensive database of water use and irrigation use efficiency for the major Lucerne Industry regions;
- analysis of the water use and irrigation use efficiency of the major Queensland Lucerne farmers and illustrates the current efficiency patterns for these farms by region;
- analysis the different types of irrigation technology used identifying best practice technologies and the impact of regional issues on the technologies;
- comparisons of the efficiency of Queensland practices across crops and regions;
- identified opportunities for improvement; and
- recommendations to industry for improved performance.

2.4 Stage 4 – Regional Presentations

Objective

Visits to Regional Centre during March 2000 to present and discuss the report with Extension Officers and Farmers in group meetings. The briefing process and information sharing will support the DPI's Continuous Improvement and Innovation Approach. It is assumed that two days on-site in each region will be required.

Process

1. Presentations at appropriate regional centres.

3. Key Measures of Irrigation Efficiency

Key Points

Key measures of efficiency investigated in the project are as follows.

- *Water Use – ML/ha*
- *Engineering Efficiency – ML used/ML input*
- *Agronomic Water Use Index – Yield/ML input*
- *Economic Water Use Index – Gross revenue/ML input*

This project uses three key measures to assess water use efficiency, Engineering Efficiency (or hydraulic efficiency), Agronomic Water Use Index and Economic Water Use Index. Within a systems context these measures can be used to link performance to practice, and practice to improvement.

Assessment and improvement of water use efficiency requires three stages

- an audit of current practices
- calculation of efficiency measures and indices
- application of efficiency measures and indices to the audit.

This enables determination of the current standard of water use efficiency in the industry, performance gaps, pathways to improvement and the benefits or goals to be achieved from improvement.

3.1 Water Use Audit

An audit requires an assessment of current industry structure including scale, water usage and economic parameters. A matrix of key parameters (hectares, megalitres, Litres (Lucerne), KgDM (Lucerne)) collected in the audit process is shown below.

Indices	**Ha**	**ML**	**KgDM**	**$**
Ha	Total			
ML	ML/Ha	Total		
KgDM	T/Ha	T/ML	Total	
$	$/Ha	$/ML	$/T	Total

3.2 Engineering Efficiency

Engineering Efficiency simply refers to:

> *"How much water was input to a given area compared to how much water the plants in that given area actually used."*

Engineering Efficiency (EE) = ***ML Used/ ML Input***

Where:

ML Used = Crop Evapotranspiration + Evaporation + Percolation (a minimum leaching requirement)

ML Input = Irrigation Water + Rainfall +/- change in Soil Moisture Balance

The engineering efficiency is expressed as a percentage with higher values representing better performance.

3.3 Agronomic Water Use Index

Agronomic Water Use Index simply refers to:

> *"How much production is achieved given the amount of water input"*

It is noted that crop production also depends on a number of inputs other than water input, however, for the purpose of this initial study, these were treated as constant.

Agronomic Water Use Index (AI) = ***Yield / ML Input***

CWUI = *Yield / ML Used*

Where:

Yield = Calculated as kilograms of dry matter (kgDM)

ML Input = Irrigation Water + Rainfall +/- change in Soil Moisture Balance

ML Used = Crop Evapotranspiration + Evaporation + Percolation (a minimum leaching requirement)

3.4 Economic Water Use Index

Economic Water Use Index simply refers to:

> *"What is the value of production given the amount of water input"*

Economic Water Use Index (EcI) = ***Gross Revenue / ML Input***

Where:

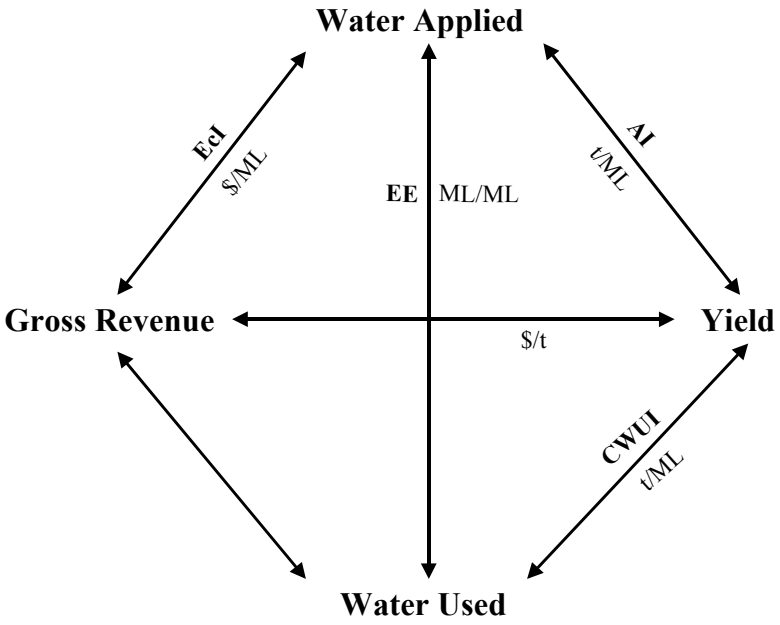
Gross Revenue = KgDM produced * Dollars per KgDM (gross dollars at farm gate)

ML Input = Irrigation Water + Rainfall +/- change in Soil Moisture Balance

Economic Water Use Index is expressed in dollars. Gross revenue has been chosen for two reasons - firstly, to remove management bias influencing input and marketing costs and, secondly, not to unnecessarily delve into the private business performance of irrigators. If revenue increases without any other changes there will be an increase in profitability, which is the key measure for all growers.

Figure 3, following, depicts the interaction between the inputs and outputs of production being considered and where in that relationship the performance measures can be applied.

Figure 1 Relationship between Key Measures of Efficiency



4. Industry Structure

Key Points

- *Total Number of Lucerne Producers – 1,602*
- *Total Number of Lucerne producers surveyed – 91*
- *Total Lucerne Area –20,526 Ha*
- *Total Water Use –175,445 ML*
- *Total Production – 371,485,277 Kg DM*
- *Total Value – $66,867,350*
- *Bores and regulated rivers make up 90 percent of water sources, being 62 percent bores and 28 percent regulated rivers*
- *59 percent of respondents have adequate water supplies currently while only 44 percent predict adequate supplies in the future*
- *The irrigation technique most widely used is the hand shift with 44 percent of respondents, followed by the soft hose winch with 29 percent of respondents*
- *93 percent of respondents do not schedule irrigation*
- *Farmers measuring and recording irrigation applications account for only 31 percent of respondents*
- *Lucerne producers are not likely to use professional advice with only 4 percent of respondents utilising irrigation advisers*
- *The main factor likely to encourage irrigators to become more efficient is the cost of water and its application cost*

4.1 Regional Production & Water Stocktake

A database has been developed using ABS production statistics (1997) applied to crop water use benchmarks using regional breakdowns. These benchmarks have been derived from grower surveys. Megalitre usage is based on irrigation applied and therefore is net of rainfall. A summary of the results is included in Table 1.

Table 1 Summary of Production and Water Audit

Summary Statistics	
Total Area (Ha)	20,526
Total Volume (ML)	175,445
Total Production (Kg DM)	371,485,277
Total Value ($)	66,867,350

Water Use by Region	**ML %**	**Cumulative %**
Inglewod	20.9%	21%
South Burnett	17.0%	38%
Lockyer Valley	16.3%	54%
Monto	11.9%	66%
Beaudesert	11.0%	77%
Darling Downs	10.8%	88%
North Coast	9.5%	97%
Rockhampton	1.4%	99%
Mackay	1.3%	100%
Brisbane Valley	0.0%	100%

Table 1 above shows that the Inglewood area is the largest user of water, using 21 percent of the total used by lucerne growers. This is followed by South Burnett and the Lockyer Valley with 17 and 16 percent respectively. Both Beaudesert and Darling Downs utilise 11 percent each. The remaining all use under one percent of the total used by lucerne producers.

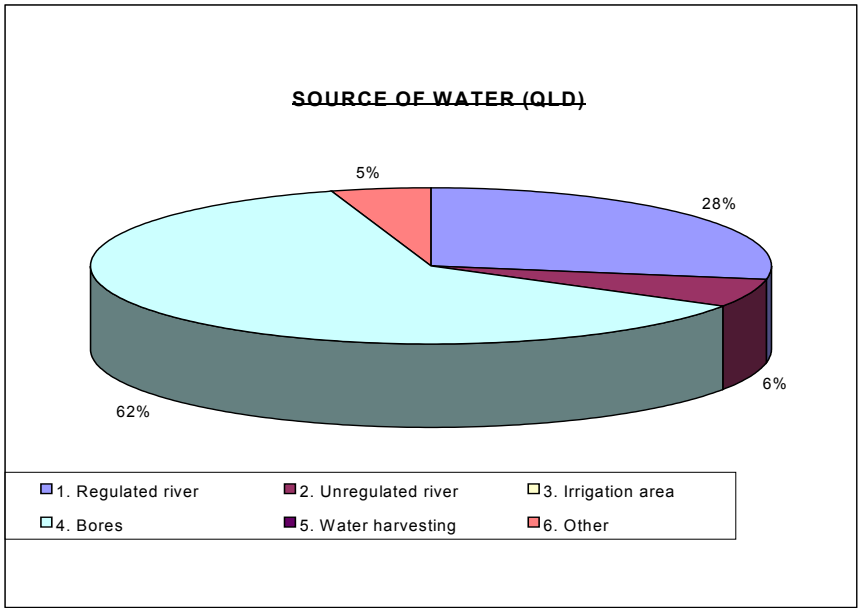
Table 2, following, summarises production and water use by regions for the state of Queensland in 1997. This data is built up from the ABS statistics for lucerne production for hay. It is important to note that the ABS statistics do not separate dryland from irrigated lucerne production. Consequently, these figures over represent irrigated lucerne production for hay. This is compensated by a time lag since the ABS census, assuming a growing industry.

Table 2 Production and Water Stocktake by Region – 1997

REGION	TOTAL Irrig. Ha (ABS)	TOTAL ML	AVERAGE ML/Ha	TOTAL $ (1997)	AVERAGE $/ML	AVERAGE $/Ha	TOTAL PROD. (Kg DM)	AVERAGE Kg DM/Ha	TOTAL GROWERS (ABS)	TOTAL GRS. SURVEYED
Beaudesert	2,444	19,252	7.9	$8,321,572	$432	$3,405	46,230,958	18,916	217	2
Brisbane Valley	1	7	7.0	$3,200	$457	$3,200	17,778	17,778	1	1
Darling Downs	2,002	18,878	9.4	$6,819,364	$361	$3,406	37,885,357	18,924	206	10
Inglewood	3,886	36,636	9.4	$13,234,144	$361	$3,406	73,523,022	18,920	277	9
Lockyer Valley	3,576	28,654	8.0	$11,511,278	$402	$3,219	63,951,545	17,884	300	22
Mackay	251	2,198	8.8	$858,586	$391	$3,421	4,769,925	19,004	19	9
Monto	3,132	20,879	6.7	$9,421,087	$451	$3,008	52,339,373	16,711	189	26
North Coast	1,949	16,669	8.6	$6,274,577	$376	$3,219	34,858,760	17,885	118	3
Rockhampton	310	2,425	7.8	$847,334	$349	$2,733	4,707,412	15,185	29	3
South Burnett	2,975	29,847	10.0	$9,576,206	$321	$3,219	53,201,147	17,883	246	6
OVERALL	**20,526**	**175,445**	**8.5**	**$66,867,348**	**$381**	**$3,258**	**371,485,277**	**18,098**	**1,602**	**91**

4.2 Water Sources

Figure 2 Sources of Water



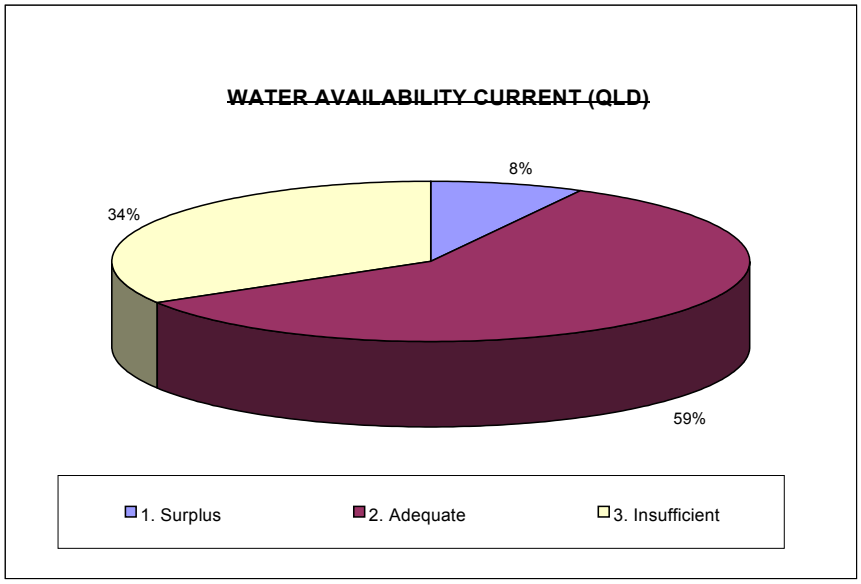
The percentages ascribed in Figure 2 are representative of the survey results. Bores supplied 62 percent of growers. Regulated water sources comprised regulated streams and irrigation areas supplying 29 percent of growers. Unregulated streams provided a water source to 6 percent of growers. Water harvesting and other miscellaneous methods delivered the remaining 5 percent.

Table 3 Regional Water Sources

	Regulated Water	Unregulated River	Irrigation Area	Bores	Water Harvesting	Other
Beaudesert	100%					
Brisbane Valley		100%				
Darling Downs	10%	20%		60%		10%
Inglewood	73%	5%		22%		
Lockyer Valley	18%	5%		59%		18%
Mackay	22%			78%		
Monto				100%		
North Coast	22%			78%		
Rockhampton	33%	33%		33%		
South Burnett	17%			83%		
Overall	**28%**	**6%**	**0%**	**61%**	**0%**	**5%**

Table 3 highlights that the use of bores is the most common water source. Bores are the primary source of irrigation in the Darling Downs, Lockyer Valley, Mackay, Monto, North Coast and South Burnett regions. The majority of growers in the Beaudesert and Inglewood regions have regulated rivers as their primary water source. The Brisbane Valley region irrigates from unregulated river supplies. Growers in Rockhampton use regulated and unregulated river supplies as well as bores.

Figure 3 Current Water Availability



When asked to rate their current availability of water, see Figure 3, 59 percent of growers believed they had adequate water availability currently, 34 percent stated they had insufficient water availability and 8 percent considered they had a surplus.

Figure 4 Regional Current Water Availability

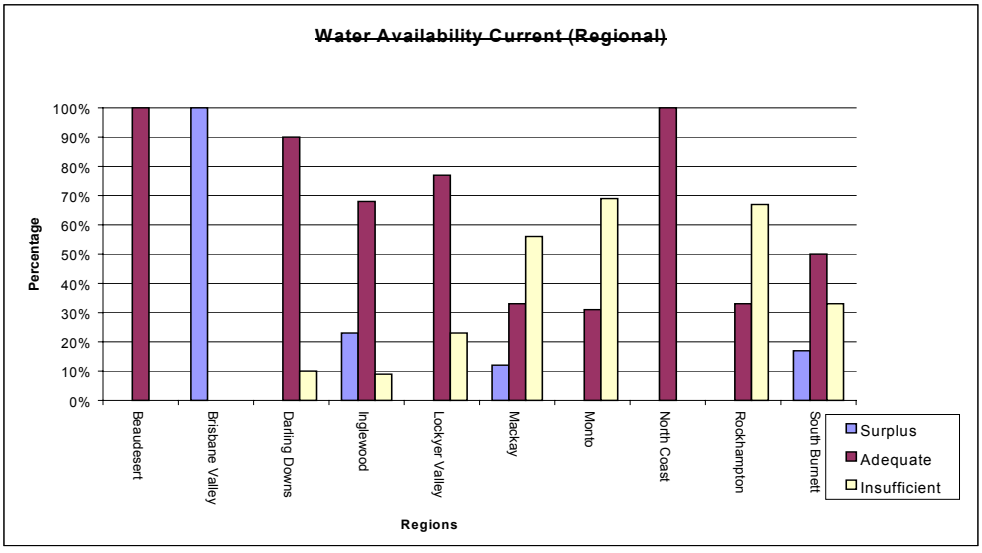
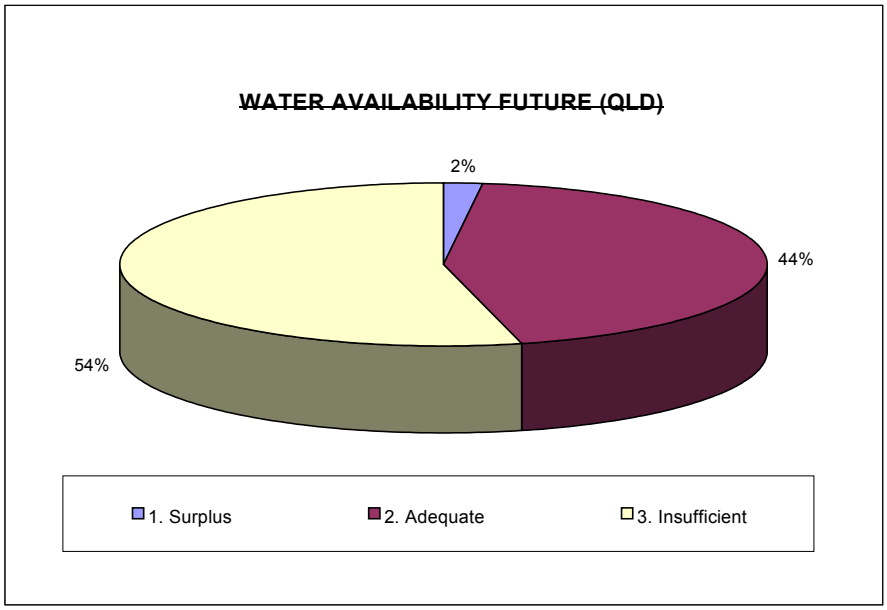


Figure 4 highlights that the majority of growers surveyed within the Beaudesert, Darling Downs, Inglewood, Lockyer Valley, North Coast and South Burnett regions believe that they have adequate water availability in the current environment. Although, the majority of growers in Mackay, Monto and Rockhampton, believe that they currently have insufficient water availability. On the other hand growers in the Brisbane Valley region believe they have a surplus of water.

It is important to note that the survey samples were not representative in all regions and therefore should be read with caution. For example, the Lockyer Valley is widely understood to have water supply issues in many of its sub regions.

Figure 5 Projected Water Availability



In Figure 5, growers were asked to forecast their future water availability. All regions expect a reduction in water availability from their current state. 54 percent of growers believed that they would have insufficient water in the future compared to 34 percent currently. 44 percent of growers believe that they will have adequate water in the future, down 15 percent from 59 percent of growers who considered they had adequate water currently. In the future 2 percent of growers believe they will have surplus water, a reduction from 8 percent who currently have a water surplus.

Figure 6 Regional Projected Water Availability

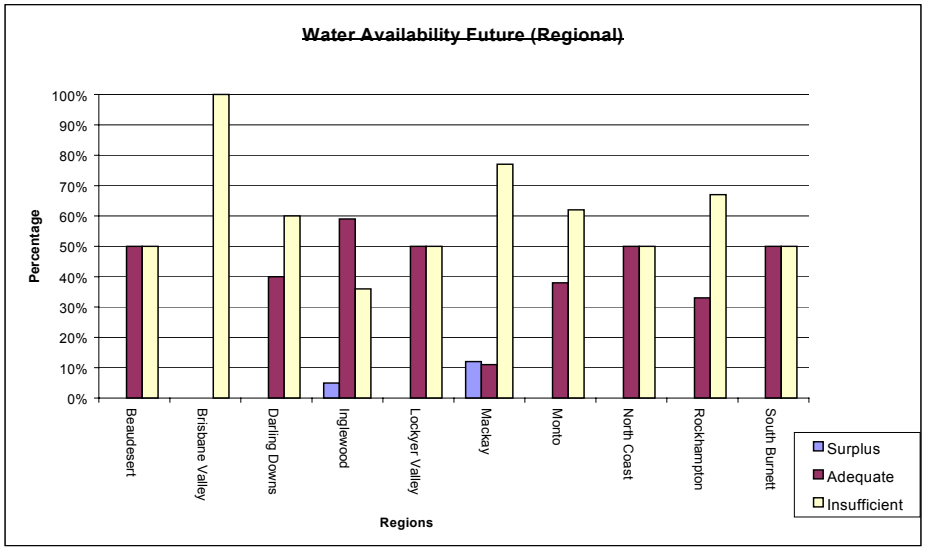
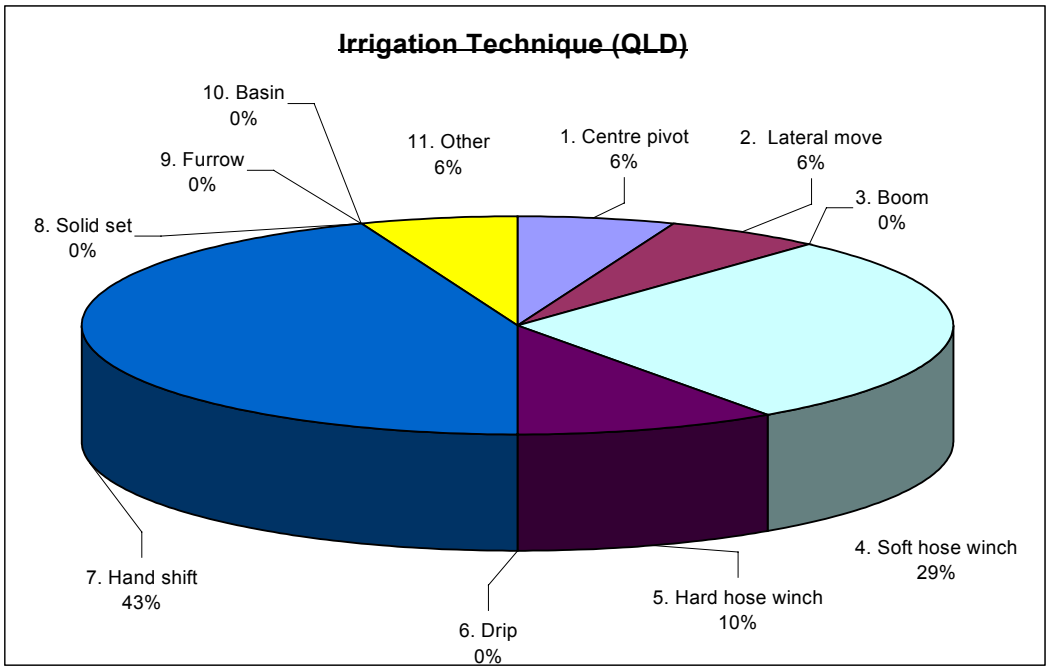


Figure 6 highlights that the majority of growers believe that they will have insufficient water availability in the future. Growers in the Brisbane Valley, Darling Downs, Mackay, Monto and Rockhampton regions believe this to be the case. The only region that believes that it will have adequate water in the future is Inglewood. Only a very few producers thought that a surplus was the future position. Half of the growers in the Beaudesert, Lockyer Valley, North Coast and South Burnett regions believe that there will be insufficient water supplies in the future and the other half think that it will be adequate.

4.3 Irrigation Infrastructure

Figure 7 Irrigation Technique (QLD)



Survey data in Figure 7 illustrates that the most commonly used irrigation technique are hand shift systems, 43 percent of respondents, followed by soft hose winches at 29 percent. On a statewide basis 55 percent of growers' use low-pressure systems, that is hand, lateral move and centre pivot. 39 percent of growers use high-pressure systems including, soft hose winch and hard hose winch (or travelling irrigators. Other methods of irrigation are employed by 6 percent of growers.

Table 4 Regional Irrigation Technique (QLD)

~~Regions~~	*Centre Pivot*	*Lateral Move*	*Boom*	*Soft Hose Winch*	*Hard Hose Winch*	*Drip*	*Hand Shift*	*Solid Set*	*Furrow*	*Other*
Beaudesert				100%						
Brisbane Valley										
Darling Downs		13%		13%	13%		61%			
Inglewood										
Lockyer Valley				100%						
Mackay	11%			22%	11%		45%			11%
Monto										
North Coast				100%						
Rockhampton				67%			33%			
South Burnett							100%			
Overall	**6%**	**6%**	**0%**	**28%**	**10%**	**0%**	**44%**	**0%**	**0%**	**6%**

Table 4 highlights that producers in the Darling Downs, Mackay and South Burnett are most likely to use the hand shift irrigation technique. The soft hose winch is most common in the Beaudesert, Lockyer Valley, North Coast and Rockhampton regions.

Figure 8 Potential to Improve Irrigation Technique

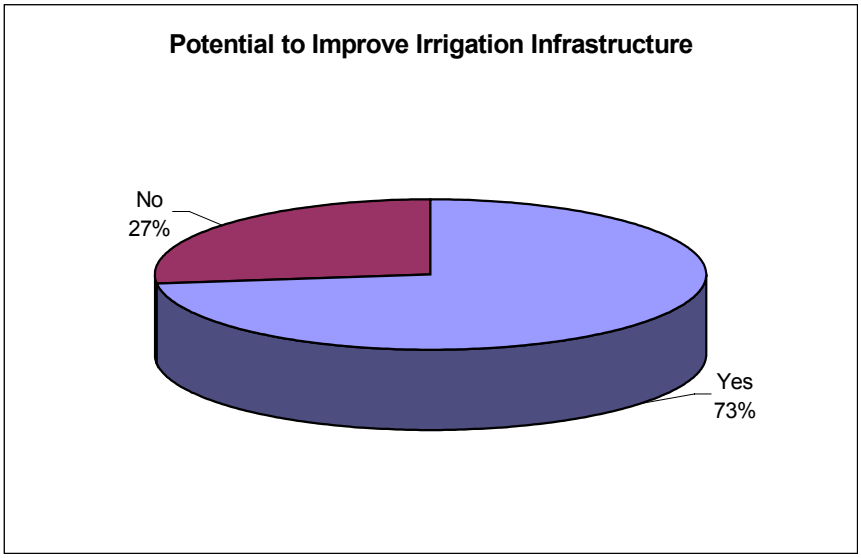
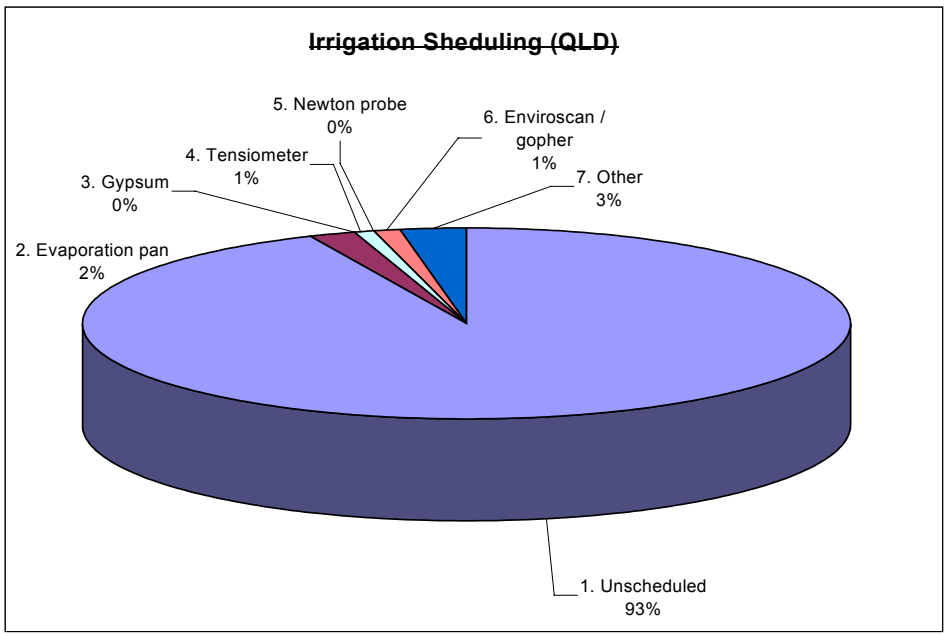


Figure 8 summarises that 73 percent of lucerne farmers believe that there is potential to improve irrigation infrastructure. 27 percent of growers do not believe there is any potential to improve irrigation infrastructure.

4.4 Management Practices

Figure 9 Irrigation Scheduling



The majority of lucerne farmers in Queensland do not schedule irrigation. Figure 9 shows that 93 percent of surveyed growers do not schedule for irrigation. Technology is used by only 2 percent of growers to support irrigation scheduling. This involves the use of tensiometers, Newton probes and enviroscans. The remaining scheduling farmers use evaporation pans and other miscellaneous methods.

Table 5 Regional Irrigation Scheduling

~~Regions~~	Unsheduled	Evaporation Pan	Gypsum	Tensiometer	Newton Probe	Enviroscan/ Gropher	Other
Beaudesert	100%						
Brisbane Valley	100%						
Darling Downs	100%						
Inglewood	100%						
Lockyer Valley	100%						
Mackay	89%			11%			
Monto	88%	8%				4%	
North Coast	67%						33%
Rockhampton	100%						
South Burnett	83%						17%
Overall State	**93%**	**2%**	**0%**	**1%**	**0%**	**1%**	**3%**

Table 10 highlights that all of the farmers surveyed in the Beaudesert, Brisbane Valley, Darling Downs, Inglewood, Lockyer Valley and Rockhampton regions do not schedule irrigation. The majority of farmers in the Mackay, Monto, North Coast and South Burnett, also do not schedule irrigation.

A small portion of scheduling does occur in Mackay, Monto and the North Coast using tensiometers, enviroscans, evaporation pans and other methods.

Figure 10 Potential to Improve Irrigation Scheduling

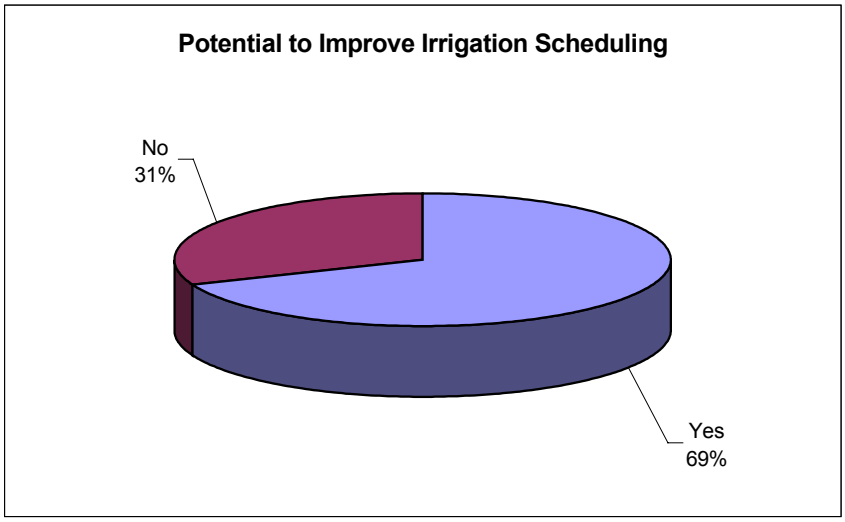


Figure 10 summarises that 69 percent of lucerne farmers believe that there is potential to improve irrigation infrastructure. 31 percent of growers believed that there was no potential to improve irrigation scheduling.

Table 6 Management Practices

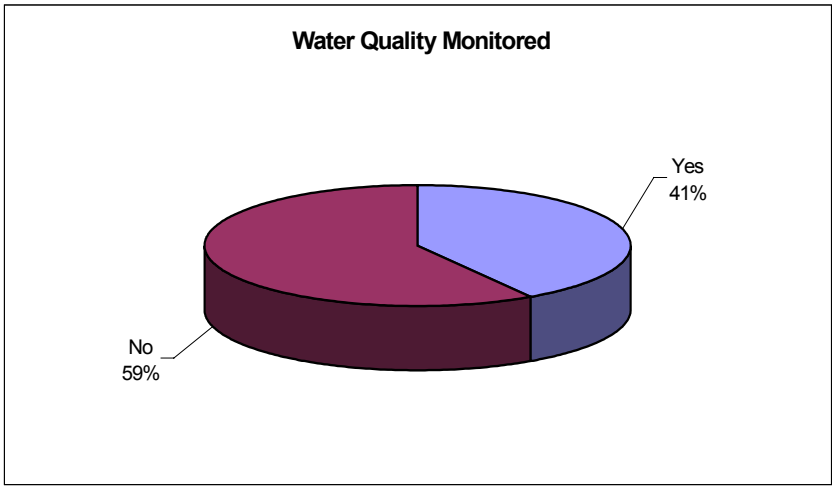
Management Practices Table	Yes	No
Measure & Record Irrigation Applications	31%	69%
Calculate Water Use Per Hectare	32%	68%
Vary Irrigation Practices for Different Soils	49%	51%

Table 6 identifies that 31 percent of lucerne producers measure and record irrigation applications as part of their management practices. Of that 31 percent only 32 percent actually calculate water use per hectare.

Variation of irrigation scheduling by soil type is practiced by 49 percent of farmers surveyed.

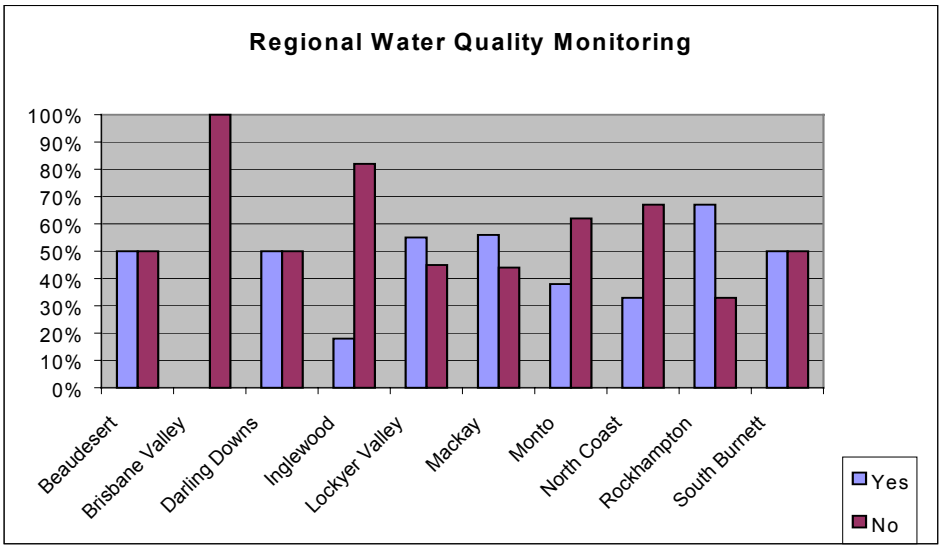
4.5 Water Quality

Figure 11 Water Quality Monitored



41 percent of farmers surveyed have monitored thier water quality.

Figure 12 Regional Water Quality Monitoring



The majority of growers in the Inglewood, Monto and North Coast regions do not monitor water quality. The majority of growers surveyed within the Lockyer Valley, Mackay and Rockhampton regions do monitor the quality of water used for irrigation. Half of the growers in Beaudesert, Darling Downs and South Burnett regions also monitor water quality.

Figure 13 Does Water Quality Affect Irrigation Management

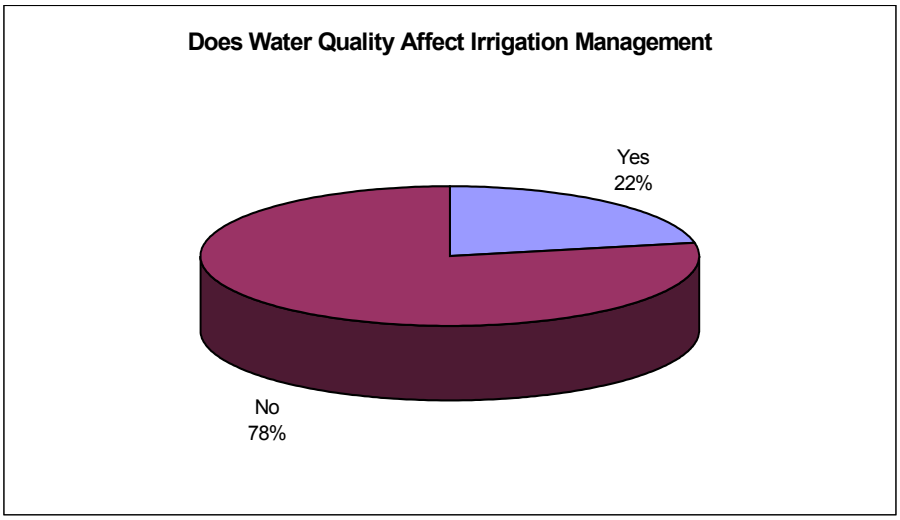


Figure 13 illustrates that 22 percent of growers said that water quality does effect irrigation management while the remaining 78 percent were not concerned about this issue.

4.6 Professional Advice

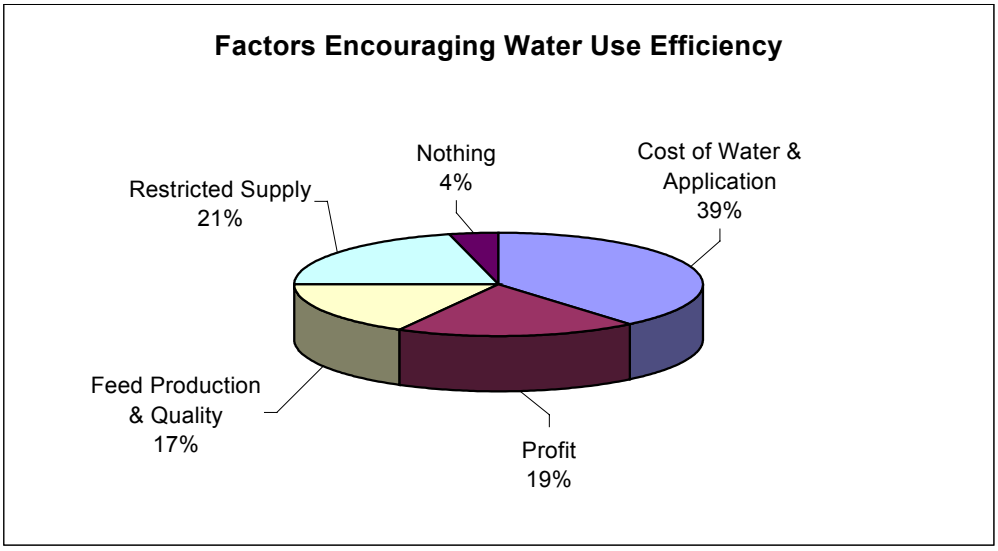
Table 7 Professional Advice

		Yes %
1	Farm Business Adviser	14
2	Agronomic Adviser	39
3	Irrigation Adviser	4

The most sought after professional advise by lucerne farmers is agronomic. Only 14 percent use farm business and 4 percent use irrigation experts.

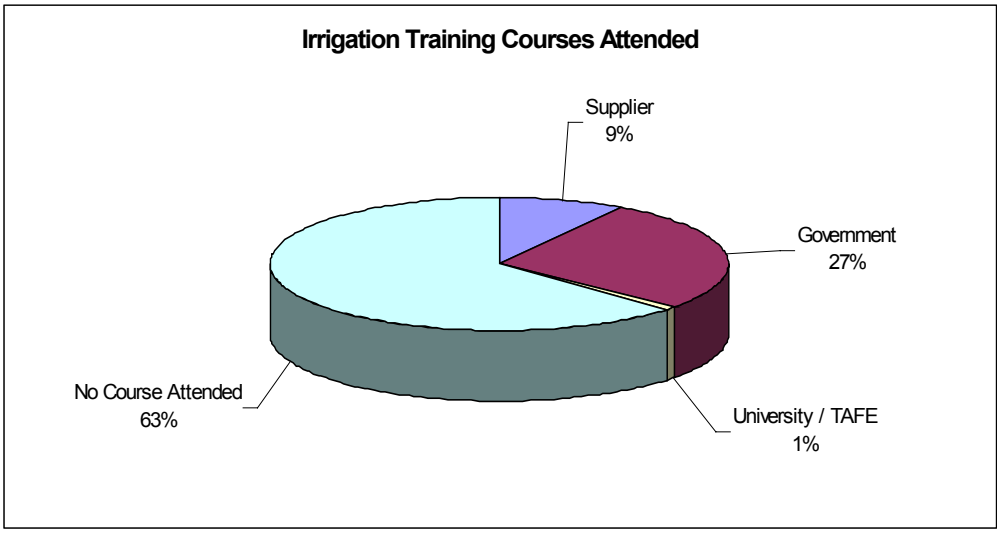
4.7 Attitudes and Perceptions

Figure 14 Factors Encouraging Water Use Efficiency



The majority of growers would be encouraged to improve water efficiency if the cost of water and its application cost where to rise. 19 percent of growers said they would be encouraged if it was likely to improve profits. If water was restricted then 21 percent of growers would improve water use efficiency and 17 percent would improve efficiency if the quantity and quality of feed production were improved. 4 percent of growers said there was nothing that would encourage them to become more water use efficient.

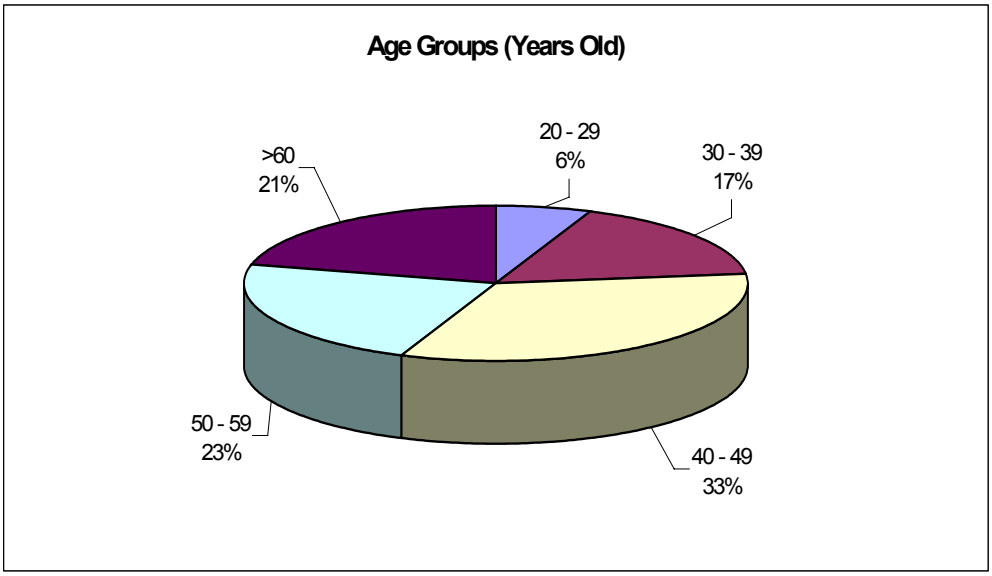
Figure 15 Attended Irrigation Training Courses



A total of 37 percent of lucerne farmers have attended an irriation course from one of the three providers listed.

4.8 Demographics

Figure 16 Age Group



Figures 16, shows 56 percent of growers are between the ages of 40 and 60 years. 23 percent are less than 40 and 21 percent are greater than 60 years.

Figure 17 Education

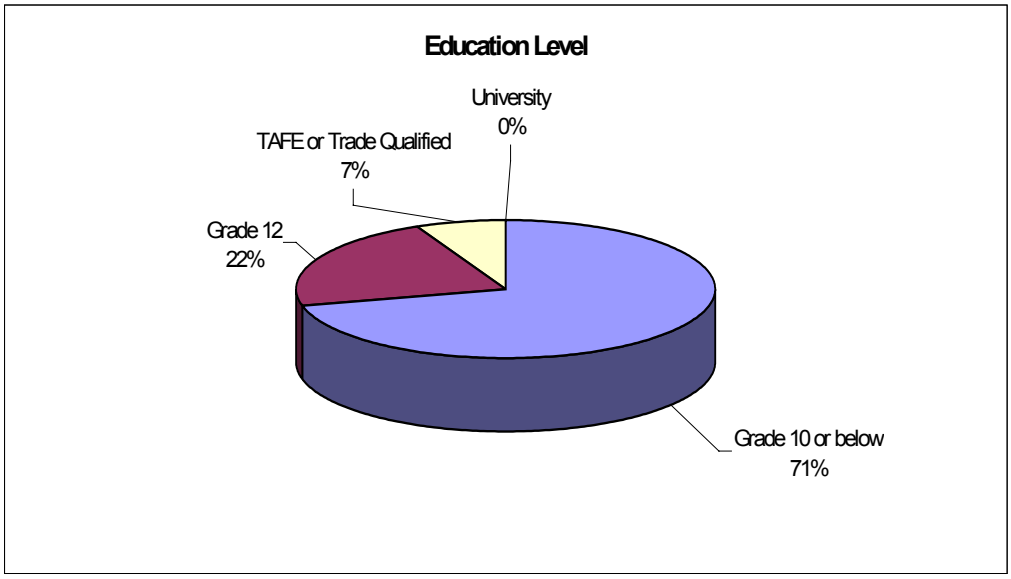


Figure 17 shows that the majority of growers, 71 percent, have been educated up to a grade 10 level. TAFE or trade qualification has been undertaken by 7 percent of growers.

5. Performance Assessment

Key Points

- *Survey results have been compiled to ascertain the relationship between high performance and average practice*
- *High performance is the intersection of best practice water use (less than average) with above average yield*
- *Analysis of the graphs that plot this relationship indicate the opportunity to improve average performance towards high performance and also there is also an opportunity to target improving high performance over time*
- *Some trends were indicated as to the best practice management processes which lead to improved performance, however, the survey data could not quantify these trends*
- *There is a need to develop research programs to quantify the benefits of best practice processes*

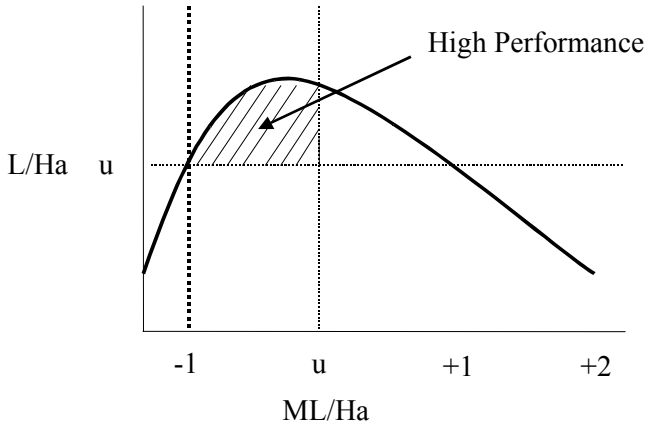
5.1 Water Use and Production Analysis

Analysis has been undertaken by averaging the performance of respondents, excepting outliers, for water use (ML input/ha), measures of agronomic water use index (KgDM/ML) and ($/ML) economic water use index. Outliers are considered to be water use or production that fall outside a standard deviation range of –1 to +3 of average (u). Details of assumptions are provided in the appendices.

The surveys asked respondents two water use questions, “how much water did you use in 1998” and “how much water would you use in a dry year”. As indicated in the Industry Structure analysis, the majority of growers do not record water application of volumes or frequency. Consequently, surveys asked respondents to estimate how much water they would normally apply at each irrigation event and how often they would normally irrigate, for both 1998 and a “dry year”. Analysis of the 1998 water use data showed high variability due to high rainfall and so for the purpose of the analysis the more consistent data set of the” dry year” has been used. Correlation of grower estimates of a “dry year” and rustic analysis indicate this to be equivalent to the water required to water a pasture in 75 percent of years.

The high performance sub set has been determined using a two step process, which is illustrated in Figure 18 below. The first step involved identifying growers within less than one standard deviation (-1) of average water use. Within this data set, those growers with above average yields were then selected as "high performance". This approach has not been able to identify best management practice, which needs to be a priority research area in the adoption program.

Figure 18 Determination of High Performance

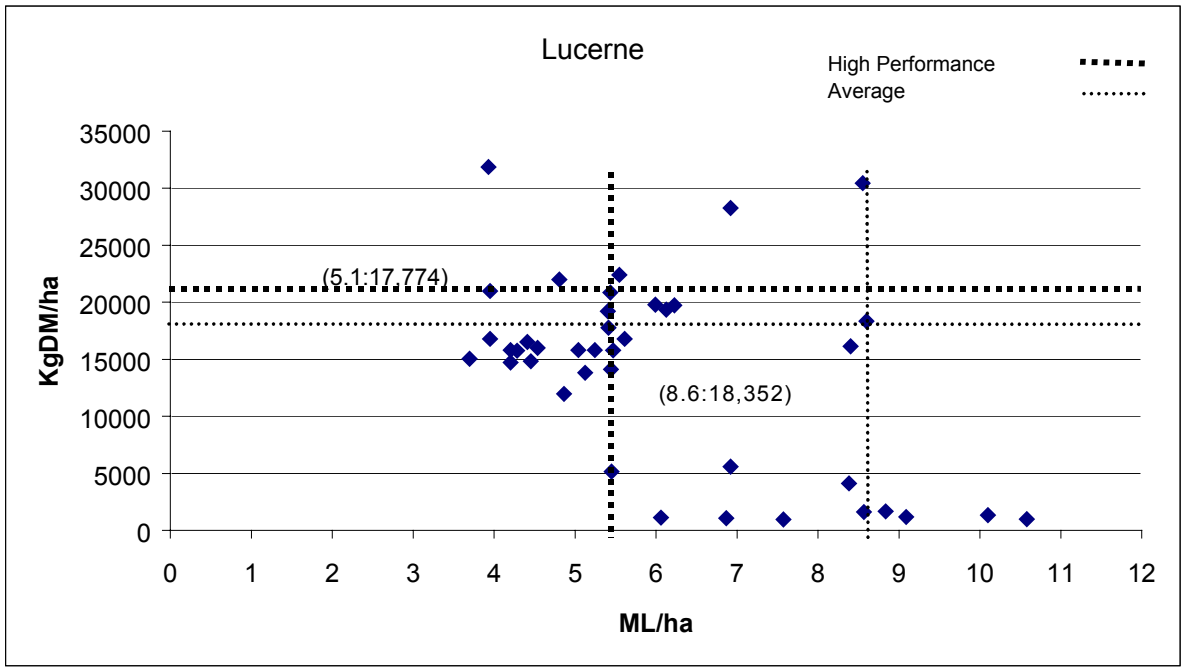


The large numbers of regions covered by the 91 surveys provides for only a small data set in each region. In order to increase the sample size to gain greater statistical certainty, a system of aggregating the responses across regions has been developed. The survey results for water use have been standardised using a relativity index for environmental differences across the regions surveyed. This is appropriate for water use, as water requirements are directly proportional to regional pan evaporation rates less effective rainfall. Production remains unadjusted, as there are no consistent differences across the regions assessed. Differences in soil type and species have not been accounted for, for the same reason.

The data supplied in Figure 19 include standardised average practice water use, which is compared to a subset, standardised high performance water use. However, in this data the average practice measures that mix water, production and dollars have been taken directly from the regionally developed industry audit, which has not been standardised. Consequently, the ML/ha average practice figures in the matrices over the page cannot be related to the other average practice figures provided there. The figures are converged to common units in the opportunities database.

Figure 19 clearly shows the variability in the available data. This is most probably driven by two key factors. Firstly, there are a number of non-water management controllable and uncontrollable variables that influence productivity and, secondly, the key water use data is reliant on farmer best estimates in most cases. However, this information could be used to clearly dissect differences in performance.

Figure 19 Lucerne - High Performance Analysis



	Std ML/ha	KgDM/Ha	KgDM/ML	$/kgDM	$/ha	$/ML
Average"	8.6	18352	2147	0.18	3303	386
High Performance	5.4	20853	3835	0.18	3753	690
Opportunity	-3.1	2501	1688	0.18	450	304

Note: " Average data taken from Audit Database

5.2 Best Practice Processes

Significant research has proven the benefits of best practice processes for improved water use. These include low pressure application systems such as centre pivots and lateral moves, which minimise evaporation losses, inaccurate application and soil compaction while also enabling more accurate and timely fertigation. Monitoring technology assists grower's irrigation scheduling through meeting plant water requirements while minimising drainage and deep percolation losses. While having the technology is one aspect, recording and management systems are needed to support this technology. Best practice support is professional advice that links crop husbandry to water management. This level of advice can be supplied from within staff or families of horticultural businesses if supported by appropriate levels of training or experience. The overall system needs to be underpinned by a "quality control" type system that enables management to record, monitor and react to changes in the process in order to maintain optimal performance.

The most widely recognised benefits of improved WUE are reduced application and water costs. The link between WUE and improved production has not received the same levels of research. Specific research projects have provided evidence that these profit related benefits could be more significant than those of a cost saving nature.

In the implementation stage there is a need to undertake greater research to quantify the practical benefits of best practice. Two avenues are indicated by the findings of this project. Firstly, monitor the management processes of those growers who are in the high performance category, where they were willing to participate. Secondly, undertake controlled research studies where research projects utilising hypothesised best practice are run in parallel to normal grower management with comparison of the performance of each. A further important avenue is to monitor the progress of growers over time.

6. Opportunities

6.1 Quantified Opportunities

Quantified opportunities for ML savings, production increases and increased returns are provided for each of the main production regions in Table 8, following. These are theoretical opportunities and assume complete attainment. However, in reality only a proportion of these can be targeted which is discussed in the next section. The complete opportunities database is provided in the appendices.

Table 8 Total ML Opportunities

REGION	ABS Ha Lucerne cut for hay	AP ML/Ha	AP ML	BP ML/Ha	BP ML	OPP ML/Ha	TOTAL OPP ML
Mackay	251	7.16	1,797	5.67	1,424	1.49	373
Monto	3,132	6.41	20,085	5.08	15,916	1.33	4,169
Rockhampton	310	6.36	1,974	5.04	1,564	1.32	410
South Burnett	2,975	6.94	20,653	5.50	16,367	1.44	4,287
Beaudesert	2,444	5.25	12,821	4.16	10,160	1.09	2,661
Brisbane Valley	1	5.30	5	4.20	4	1.10	1
Lockyer Valley	3,576	6.31	22,553	5.00	17,872	1.31	4,681
North Coast	1,949	6.94	13,533	5.50	10,724	1.44	2,809
Darling Downs	2,002	7.63	15,282	6.05	12,111	1.58	3,172
Inglewood	3,886	7.63	29,658	6.05	23,503	1.58	6,155
Total	**20,526**	**6.74**	**138,361**	**5.34**	**109,644**	**1.40**	**28,716**

Figure 20 Total KgDM Opportunity

REGION	ABS Ha Lucerne cut for hay	AP KgDM/Ha	AP KgDM	BP KgDM/Ha	BP KgDM	TOTAL OPP KgDM
Mackay	251	18,996	4,769,925	22,973	5,768,543	998,618
Monto	3,132	16,712	52,339,373	17,780	55,685,086	3,345,713
Rockhampton	310	15,166	4,707,412	14,642	4,544,985	-162,427
South Burnett	2,975	17,885	53,201,147	20,363	60,574,322	7,373,175
Beaudesert	2,444	18,920	46,230,958	22,789	55,685,637	9,454,679
Brisbane Valley	1	17,778	17,778	20,121	20,121	2,343
Lockyer Valley	3,576	17,885	63,951,545	20,363	72,814,623	8,863,079
North Coast	1,949	17,885	34,858,760	20,363	39,689,855	4,831,094
Darling Downs	2,002	18,920	37,885,357	22,789	45,633,280	7,747,923
Inglewood	3,886	18,920	73,523,022	22,789	88,559,192	15,036,171
Total	**20,526**	**1,298,346**	**406,344,037**	**20,899**	**428,975,644**	**57,490,368**

Figure 21 Value of Total ML Opportunity

REGION	ABS Ha Lucerne cut for hay	AP ML/Ha	AP ML	BP ML/Ha	BP ML	OPP ML/Ha	TOTAL OPP ML	Opportunity $/ML AP	Value ML Opportunity
Mackay	251	7.16	1,797	5.67	1,424	1.49	373	$391	$145,645
Monto	3,132	6.41	20,085	5.08	15,916	1.33	4,169	$451	$1,880,925
Rockhampton	310	6.36	1,974	5.04	1,564	1.32	410	$349	$143,185
South Burnett	2,975	6.94	20,653	5.50	16,367	1.44	4,287	$321	$1,375,305
Beaudesert	2,444	5.25	12,821	4.16	10,160	1.09	2,661	$432	$1,150,205
Brisbane Valley	1	5.30	5	4.20	4	1.10	1	$475	$523
Lockyer Valley	3,576	6.31	22,553	5.00	17,872	1.31	4,681	$402	$1,880,373
North Coast	1,949	6.94	13,533	5.50	10,724	1.44	2,809	$376	$1,057,237
Darling Downs	2,002	7.63	15,282	6.05	12,111	1.58	3,172	$361	$1,145,773
Inglewood	3,886	7.63	29,658	6.05	23,503	1.58	6,155	$361	$2,223,569
Total	**20,526**	**6.74**	**138,361**	**5.34**	**109,644**	**1.40**	**28,716**	**$381**	**$10,944,703**

Figure 22 Value of Total KgDM Opportunity

REGION	ABS Ha Lucerne cut for hay	AP KgDM/Ha	AP KgDM	BP KgDM/Ha	BP KgDM	TOTAL OPP KgDM	Opportunity AP $/KgDM	OPP $ Lucerne
Mackay	251	18,996	4,769,925	22,973	5,768,543	998,618	0.18	179,751
Monto	3,132	16,712	52,339,373	17,780	55,685,086	3,345,713	0.18	602,228
Rockhampton	310	15,166	4,707,412	14,642	4,544,985	-162,427	0.18	-29,237
South Burnett	2,975	17,885	53,201,147	20,363	60,574,322	7,373,175	0.18	1,327,172
Beaudesert	2,444	18,920	46,230,958	22,789	55,685,637	9,454,679	0.18	1,701,842
Brisbane Valley	1	17,778	17,778	20,121	20,121	2,343	0.18	422
Lockyer Valley	3,576	17,885	63,951,545	20,363	72,814,623	8,863,079	0.18	1,595,354
North Coast	1,949	17,885	34,858,760	20,363	39,689,855	4,831,094	0.18	869,597
Darling Downs	2,002	18,920	37,885,357	22,789	45,633,280	7,747,923	0.18	1,394,626
Inglewood	3,886	18,920	73,523,022	22,789	88,559,192	15,036,171	0.18	2,706,511
Total	**20,526**	**1,298,346**	**401,598,047**	**#DIV/0!**	**428,975,644**	**57,490,368**	**0.18**	**10,348,266**

6.2 Target Opportunities

Key Points

- *Opportunities are assessed as water savings, production improvement and increased revenue generated by moving from average to best practice*
- *Targeting a proportion of opportunities establishes an 12 percent improvement in WUE*
- *Target opportunities equate to 4,595 ML and 9,198,459 KgDM*
- *The value of these target opportunities is $1,655,723 from direct yield increases and $1,750,551 from the opportunity cost of the water savings, providing a combined economic benefit of $3,406,273*
- *Regions where the greatest improvement opportunities exist are Inglewood, South Burnett, Lockyer Valley, Monto, Beaudesert, Darling Downs and the North Coast*

The following table has been used to calculate water use efficiency goals from the opportunities in Section 6.1. The goals developed indicate realistic water savings of 4,595 ML as well as an increase in production of 9,198,459 KgDM, which at average price per KgDM can be valued at $1,655,723. The value of the water saved is its opportunity cost (current practice yields per ML at average value of $0.18 per KgDM) through increased productivity, which is $1,750,551. Thus the combined economic benefit from the achievement of these goals is likely to be in the order of $3,406,273.

The approach used to arrive at these goals uses the statewide opportunities identified by moving from current performance to high performance. Of this opportunity set only forty percent of growers can be predicted to respond. The remaining growers are likely to be either unwilling to change, afford minimal impact or are already at high performance. Experience in process improvement across a number of industries has consistently proven this forty- percent figure.

The next step applies a stretch target to this response percentage. Experience says that forty percent is again the most realistic number. This provides enough of a "stretch" to motivate and encourage innovation while still appearing achievable. The application of these percentages (opportunity, response and stretch) provides the goal for improvement in water use and yield.

Table 9 Water Use Efficiency Goal

Input/Output	Current Performance	Opportunity	Response %	Stretch Target %	Goal	Goal %	Goal Value
ML	138,361	28,716	40%	40%	4,595	3.3%	$1,750,551
KgDM	406,344,037	57,490,368	40%	40%	9,198,459	2.3%	$1,655,723
Water Use Efficiency Goal						***5.6%***	
Value of Water Use Efficiency Goal							***$3,406,273***

The addition of the two components of megalitres and KgDM, in their common unit of KgDM per megalitre, establishes the Water Use Efficiency Goal of five percent. This accepts

that a decrease in water is an increase in litres per megalitre, as is an increase in litres. Growers are likely to make gains in one or the other or in smaller components of both. The Water Use Efficiency Goal takes this into account.

The approach of combining the two potential areas of gain ensures that the means of improvement is not prescribed. This enables growers, crop industries and regions to individually seek and implement improvement in the way most appropriate to their situation. This accepts that there are opportunities to make gains in all regions.

Table 10, below, converts the opportunities to goals for each of the regions.

Table 10 Goals by Region

REGION	TOTAL OPP ML	ML Goal	ML Goal %	TOTAL OPP KgDM	KgDM Goal	KgDM Goal %
Mackay	373	60	3.3%	998,618	159,779	3.3%
Monto	4,169	667	3.3%	3,345,713	535,314	1.0%
Rockhampton	410	66	3.3%	-162,427	0	0.0%
South Burnett	4,287	686	3.3%	7,373,175	1,179,708	2.2%
Beaudesert	2,661	426	3.3%	9,454,679	1,512,749	3.3%
Brisbane Valley	1	0	3.3%	2,343	375	2.1%
Lockyer Valley	4,681	749	3.3%	8,863,079	1,418,093	2.2%
North Coast	2,809	449	3.3%	4,831,094	772,975	2.2%
Darling Downs	3,172	507	3.3%	7,747,923	1,239,668	3.3%
Inglewood	6,155	985	3.3%	15,036,171	2,405,787	3.3%
Total	**28,716**	**4,595**	**3.3%**	**57,490,368**	**9,198,459**	**2.3%**

7. Key Outcomes

Key Points

- *The seven main production regions use 97 percent of the irrigation to produce the majority of the states irrigated lucerne*
- *Current water use is 8.5 ML/Ha for winter and summer production respectively*
- *54 percent of respondents predict future water shortages*
- *39 percent of those surveyed use less than ideal application systems*
- *93 percent do not use technology to assist in irrigation scheduling*
- *63 percent of those surveyed have never attended an irrigation training course*
- *36 percent of farmers could be encouraged to become more water use efficient through profit drivers*
- *there is a need to undertake future research into the effects of water management on lucerne production, best management practices and on-farm management systems*

The key outcomes reviews the survey findings of the structure of the Queensland Lucerne Industry, targets and areas recommended for future research.

7.1 Industry Structure

Scale

There are approximately 20,500 hectares of irrigated lucerne in Queensland. This area produces approximately 371,000 tonnes of dry matter valued at $66 million dollars. The main production areas, in descending order are:

- Inglewood
- South Burnett
- Lockyer Valley
- Monto
- Beaudesert
- Darling Downs
- North Coast

Water Use Efficiency

There is currently 175,445 ML of water used for irrigated lucerne. The current measures of water use efficiency and the opportunities for improvement at high performance are included in the Tables 11 and 12, below.

Table 11 Current Measures of Water Use Efficiency

Efficiency Measure	
Water Use	8.55 ML/Ha
Agronomic Water Use Index	2,117 KgDM/ML
Economic Water Use Index	$381 $/ML

Table 12 High Performance Measures of Water Use Efficiency

Efficiency Measure	
Water Use	5.34 ML/Ha
Agronomic Water Use Index	3,912 KgDM/ML
Economic Water Use Index	$704 $/ML

Water Sources

The water supply for growers surveyed was mainly from bores, 62 percent. 29 percent of growers source water from regulated systems. While 59 percent of respondents currently have adequate water, 54 percent predict future shortages.

Application Systems

On a statewide basis 55 percent of respondents use low-pressure systems with 39 percent using less ideal high-pressure systems. Furrow was used by 2 percent. 73 percent of those surveyed considered there is potential to improve their irrigation infrastructure.

Irrigation Scheduling

The large majority, 93 percent of respondents, do not use any form of objective measurement to assist with irrigation scheduling. However, 69 percent believe there is potential to improve their scheduling techniques.

Management

Only 31 percent of those surveyed measure and record their irrigation applications, of which 32 percent calculate water use per hectare.

39 percent of lucerne farmers interviewed using an agronomist. 14 percent use a business advisor and only 4 percent seek professional irrigation assistance.

63 percent of lucerne farmers surveyed have not attended any form of irrigation training course while all of those surveyed undertake irrigation.

Attitude towards Water Use Efficiency

The major incentive to encourage water use efficiency was believed to be the cost of water and its application, 39 percent. However, the profit drivers of revenue (19 %) and feed production and quality (17%) would encourage 36 percent.

Demographics

56 percent of lucerne farmers surveyed are between 40 and 60 years of age. The majority of lucerne farmers have been educated up to and including grade 10, 71 percent. A further 22 percent went on to grade 12 with the remaining 7 percent being trade or TAFE qualified.

7.2 Targets

Targets have been set at a WUE saving of 6 percent, either from decreased water use or increased production or a combination of both.

Regions

While it is important that the RWUE adoption program provide extension assistance to the Queensland industry as a whole, the main production regions will generate the majority of the gains. The seven regions of Inglewood, South Burnett, Lockyer Valley, Monto, Beaudesert, Darling Downs, and the North Coast make up 97 percent of the current water use. These same regions are naturally the biggest producers of lucerne from irrigated pasture.

Issues and Limitations

It is significant that 93 percent of growers do not use technology to assist in irrigation scheduling and, thus, this is the major area for improvement.

Thirty nine percent of those surveyed have older less efficient high-pressure application systems. The cost to upgrade irrigation systems, especially in a climate of increased competition through deregulation, will be a barrier to improvement. Therefore, the biggest gains are likely to be made from better managing the current systems through improved scheduling and management.

7.3 Future Research

Lucerne Research

While this project has established high performance through analysis of survey data, there is a need to verify this in each of the regions. There remains a need to identify and quantify the linkages between water management and high quality yields. This is especially important given that a significant motivator for growers to improve water use efficiency was profit and improved feed production (36 percent of respondents).

Current theoretical water use models rely heavily on crop factor data, however, the theory and derivation behind these crop factors is quite arbitrary and imprecise. There is a real need to develop this data if engineering water use index goals are to be set and managed.

Best Management Practices

There is a need to undertake greater research to quantify the practical benefits of best practice. Two avenues are recommended. Firstly, monitor the management processes of those growers who are in the high performance category, where they're willing to participate. Secondly,

undertake controlled research studies, where research projects utilising hypothesised best practice are run in parallel to normal grower management comparing of the performance of each. A further important avenue is to monitor the progress of growers over time.

Management Systems

There is a need to integrate water management with farm management. Many growers and consultants have managed water in isolation. There is an opportunity to manage irrigation as part of a whole farm system and therefore add value to other farm practices. Consequently, there is a need to identify and/or develop appropriate systems.

8. Adoption Program Objectives

Key Points

- *Development of the adoption program needs to be a consultative approach involving all stakeholders*
- *The adoption program needs to establish water use benchmarks and define pathways for improvement*
- *The extension program needs to be tailored to match the pshycographic segments of the farmers involved*
- *The program needs to motivate increased returns*
- *There needs to be a defined management plan that focuses on the 12 percent goal, establishes key performance indicators, undertakes regular reviews and responds when necessary*

Adoption objectives need to be developed in conjunction with growers, local area groups and irrigation extension officers. The following approach is suggested to initiate the setting of objectives.

1. Establish water use requirements
    - Benchmarks by region
    - Understand actual water use given crop husbandry requirements
    - Establish the impact of water and other farm management practices on quality and quantity of production
2. Define clear pathways towards improved water use
    - Best farm and water management practices
    - Provide the motivation to improve
    - Provide support for the use of technology in terms of measuring and responding
    - Get involved at a farm level – micro measure and manage the process
3. Manage extension and communication
    - Extension approach needs to be developed to add value for best practice growers, improve the early majority and create awareness amongst the late majority in WUE efficiency
    - Establish paths of information dissemination
    - Create a breadth of approach amongst service providers
    - Incorporate and encourage a movement to private sector led solutions.

4. Motivate increased returns for water inputs
    - Improve existing performance
    - Understand the true cost value of irrigation water to lucerne to enable fair valuation and better decision making regarding alternatives uses or sale
5. Manage the overall program
    - Focus and champion the 6 percent WUE goal
    - Establish implementation plans and progress targets
    - Establish key performance targets for regions and key personnel
    - Review, monitor and respond to progress

9. Evaluation of Value & Accuracy of Information

Key Points

- ABS Statistics are the most accurate data set available on a statewide basis however the accuracy of this data is limited by a time lag from collection and the accuracy of information supplied by growers
- Survey information is of high value but is inherently variable due to a high anecdotal component in responses
- Theoretical modeling has been undertaken using Rustic software. The results of this modeling are limited by the quality of input data. Crop factors, a sensitive input to the model, are not well known or understood

The analysis compiled in this report provides value-added outcomes in line with the project goals using key data of high value but variable accuracy. The key data sources have been ABS statistics, DNR customer databases, international and national literature searches, grower surveys, theoretical modeling and regional advisory information. The value and accuracy of this information is discussed in the following sections.

Readers will note minor variations in some data reported which are due to rounding differences.

ABS Statistics

This is the most comprehensive data set available. However, it provides data for the period of 1997, which means there is a time lag to current production. The other key driver of variability in this information is the level of quality control at source. Information is collated from statistical surveys sent to growers. The accuracy of the input information has been questioned on the basis of growers either wanting to maintain their confidentiality or from being careless in forming responses.

ABS statistics have been used in the industry audit to establish production area, yields and returns for the lucerne industry in Queensland. The production area component has then been used in the development of opportunities, which have been applied to survey results. The ABS census data has now been replaced by sample data collection, which will reduce its reliability in the future.

Farmer Surveys

Extension officers and temporary employees, under the management of DPI, have conducted the farmer surveys. As indicated in the Industry Structure analysis, the majority of growers do not record water application of volumes or frequency. Consequently, surveyors asked respondents to estimate how much water they would normally apply. As a result, grower survey data is of high value but of variable accuracy. However, the impact of inaccurate data has been minimised by excluding outliers.

Survey results of water use, yields and returns have been applied to the production area, derived from the ABS databases, to establish the industry audit and opportunities.

Theoretical Modeling

Theoretical modeling has been undertaken using the DNR developed software package Rustic. Rustic was used to calculate theoretical crop water requirements for a winter and summer pasture in each region and assumed no conveyance, drainage or deep percolation losses, with a goal to calculate Engineering Water Use Index. Rustic, however, consistently returned higher crop water requirements than was observed in high performance growers. Potential causes are an inability in the Rustic model to account for drought conditions artificially induced for crop husbandry purposes, and inaccurate input information for crop factors. Crop factors have been taken from the latest FAO publication 56. Rustic is highly sensitive to changes in these crop factors, however, crop factors are not well known, nor have they been thoroughly researched. Future research is required in this area of Engineering Water Use Index is to be well understood and managed.

10. References

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11. Appendices

11.1 Assumptions

- $/kgDM have been calculated to create a common unit of measurement between, hay, haylage and silage. The average value has then been used as a constant ($0.18) which has been used in all value calculations.

- Standard deviation calculations have been undertaken to eliminate outliers from the data and were calculated as follows:
  -1 Stdev - to eliminate outliers significantly under the mean
  +4 Stdev - to eliminate outliers significantly above the mean.
  Using these boundaries the following standardised ML/Ha were calculated for both the actual and dry year models:

- ML/Ha

Before Stdev – Average =	5.71	After Stdev – Average =	6.38
Stdev =	2.69	Stdev =	2.35 .
-1 =	3.02		
+1 =	8.40		
+2 =	11.09		
+3 =	13.78		
+4 =	16.47		

11.2 Databases

Printouts of the Lucerne Industry Audit Database and Lucerne Opportunities Database are provided in the following pages. They are also available in "soft copy" in Microsoft Excel.